Bulletin No. 105

Calorimeter Selection Criteria

Factors that influence the selection of a calorimeter.

There are a number of factors which should influence a user in his or her selection of a calorimeter. In general, the following four areas will help define the correct calorimeter choice.

1. Precision
2. Workload
3. Type of Analysis: including Test Method, Sample Size and Sample Characteristics
4. Budget

Precision

Some instruments, by design, are able to provide data with greater precision than others. Instruments may be classified based on their expected performance and this classification is used to define limits by which data can be assessed.

Parr Calorimeter Model	Sigma or Instrument Class	Expected Accuracy (Benzoic Acid, 1.0g)
6400 Automatic Isoperibol Calorimeter	0.10%	11373 ± 34 Btu/lb
6300 Automatic Isoperibol Calorimeter	0.10%	11373 ± 34 Btu/lb
6200 Isoperibol Calorimeter	0.10%	11373 ± 34 Btu/lb
6100 Compensated Jacket Calorimeter	0.20%	11373 ± 68 Btu/lb
1341 Plain Jacket Calorimeter	0.30%	11373 ± 102 Btu/lb
6725 Semi-micro Calorimeter	0.40%	11373 ± 137 Btu/lb

Standard methods usually define a level of precision and/or accuracy, and therefore the method parameters must be considered. Precision and accuracy in relation to instrumentation is discussed further in Tech Note 100 “Precision and Accuracy – Assessing Your Calorimeter” and must be studied and understood in order to select the most appropriate calorimeter.

Workload

The 6400 and 6300 Automatic Isoperibol Calorimeters are designed to handle a large volume of samples. Loading of the sample involves a simple 1/8th turn of the bomb head in the unit. The unit then automatically fills the bomb and bucket, ignites the sample, monitors the temperature rise and flushes the system once the reaction is complete. Users will find that they can operate multiple calorimeters with ease. The operator time per test is estimated to be 1 minute and therefore it is possible for one operator to manage multiple units simultaneously.

The 6400 and 6300 operate similarly. The main differences are that the 6400 has an integrated water handling system and pressurized rinse water while the 6300 has an optional external water handling system and pumped rinse water.

The 6200 Isoperibol Calorimeter and the 6100 Compensated Jacket Calorimeter can analyze just as many samples per instrument as the 6300 calorimeter; however, there is additional operator time per test and therefore fewer instruments can be operated at the same time. The user will need to fill and rinse the bomb as well as fill and drain the bucket. This requires repetitive action and therefore is recommended for a smaller number of samples. The operator time per test is estimated to be 6 minutes.

The 1341 Plain Jacket Calorimeter requires significant user time. Along with filling and rinsing the bomb and filling and draining the bucket with water, the user must record the temperatures during the course of the reaction. The estimated time that the user will spend with this instrument is 25 minutes per test. This process can be simplified for the user by adding the 6772 Calorimetric Thermometer. The thermometer will ignite the sample after the established pre-period and record the temperature change. It will also determine the energy equivalent factor of the system after standardization and apply the heat leak correction to subsequent samples. (See Manual 202M, Introduction to Bomb Calorimetry for more information on standardization).

Type of Analysis

The Parr 6400 Automatic Isoperibol Calorimeter, 6300 Automatic Isoperibol Calorimeter, and 6200 Isoperibol Calorimeter utilize a controlled water jacket. The water jacket is maintained at a fixed temperature, completely surrounding the bomb and bucket. Many standard methods require a water jacketed system such as ASTM D5865 and DIN 51900. If that is the case, the user's choice will be reduced to these three models.

The 6200 calorimeter is able to provide the highest level of precision to the user. This is possible because each component of the system can be controlled by the operator. For example, the manual release of the bomb allows the user to have complete control over the exhaust of the vessel. This may be critical when analyzing the subsequent combustion products. Many such analytical methods are discussed in manual 207M, Analytical Methods for Oxygen Bombs.

The 1108 series and 1138 oxygen bombs are designed to handle approximately 1 g of a sample that liberates 5000 – 8000 calories using an oxygen charging pressure of 30 atm. The 1108P Oxygen Bomb is a version of the standard 1108 that it is constructed with a semi-permanent fuse wire to be used with cotton thread in place of the more traditional thin gauge fuse wire. The 1108R Oxygen Bomb is designed with a compression ring seal rather than an o-ring and utilizes the same semi-permanent fuse design found in the 1108P. Specific calorimeters are required for some of these bomb types as outlined in the table below.

Alloy 20 Cb3 is the standard alloy of construction for the 1108 Oxygen Combustion Bomb and the 1138 Oxygen Combustion Bomb. This alloy is resistant to sulfuric and nitric acid, common by-products of the combustion process. Alloy G30 is recommended for use with samples that contain a higher level of fluorine or chlorine as well as being resistant to sulfuric and nitric acid. Bombs constructed of this alloy are marked with "CL".

Finally, the choice of bomb style may affect the calorimeter chosen. Bomb choice is dictated by sample size and alloy of construction. For example, the Parr 1109A Semi-micro Oxygen Bomb is designed for small samples such as marine biology or ecological studies. It may also be used when sample size is limited. This 22 mL bomb will handle samples that range from 25 to 200 milligrams, liberating 52 to 1200 calories when burned in oxygen, using initial pressures

up to 35 atmospheres. Outputs of up to 2400 calories can be accommodated if the sample is self-oxidizing, provided it is burned in an inert atmosphere and does not produce gas.

On the other end of the Parr bomb family spectrum, the Parr 1104 Oxygen Bomb is designed for combustion tests of explosives and other fast burning, high energy samples, that burn with extreme violence. The 1104 Oxygen Bomb is also recommended for use with materials whose combustion characteristics are unknown or unpredictable. The 1104 Oxygen Bomb is a heavy-walled, 240 mL vessel. It will handle samples liberating up to 12,000 calories using an oxygen charging pressure up to 45 atm (665 psig). Samples of smokeless powder weighing up to 4 grams have been burned in this bomb, but the requirements for safe operation vary so widely with different materials that it is difficult to make general statements regarding allowable sample size.

The following table highlights the different bomb choices for the Parr Calorimeter line.

	6400	6300	6200	6100	1341	6725
1138/ 1138CL	X	X				
1108/ 1108CL			X	X	X	
1108P/ 1108PCL			X	X	X	
1108R/ 1108RCL			X	X	X	
1104			X	X	X	
1109A			X	X		X

Budget

Price will often be a deciding factor in the purchase of a calorimeter and will, of course, be taken into account. For current pricing or additional assistance on choosing the appropriate calorimeter, please contact the sales department at Parr Instrument Company, parr@parrinst.com.

Calorimeter Overview

Characteristics	6400 Automatic Isoperibol Calorimeter	6300 Automatic Isoperibol Calorimeter	6200 Isoperibol Calorimeter	6100 Compensated Jacket Calorimeter	1341 Plain Jacket Calorimeter	6725 Semi-micro Calorimeter
Operator Time per Test	1 Minute	1 Minute	6 Minutes	6 Minutes	25 Minutes	6 Minutes
Repeatability (%RSD)	0.10%	0.10%	0.10%	0.20%	0.30%	0.40%
Calorimeter Type	Isoperibol	Isoperibol	Isoperibol	Compensated	Static	Static
Number of vessels	Up to 4	Up to 4	Up to 4	Up to 4	1	1
Closure Type	Quick-lock	Quick-lock	Screw Cap	Screw Cap	Screw Cap	Screw Cap
Tests per Hour	6-8 as equipped	6 - 8 as equipped	4-8 as equipped	4-8 as equipped	2	3
Bomb Type & Bucket	Semi-Fixed Cylinder/ Removable Head	Semi-Fixed Cylinder/ Removable Head	Removable Bomb & Bucket	Removable Bomb & Bucket	Removable Bomb & Bucket	Removable Bomb Dewar Flask
Bucket	Fixed	Fixed	Removable	Removable	Removable	Fixed
Bucket Filling	Automatic	Automatic	Manual	Manual	Manual	Manual
Oxygen Filling	Automatic	Automatic	Semi-automatic	Semi-automatic	Manual	Manual
Bomb Washing	Automatic pressurized	Automatic pumped	Manual	Manual	Manual	Manual
Water handling system	Integrated	Optional external	Optional external	Optional external	None	None
Program Modifications	Touchscreen	Touchscreen	Touchscreen	Touchscreen	None	Touchscreen
Memory	1000 Tests	1000 Tests	1000 Tests	1000 Tests	None	1000 Tests
Printer Connection	Ethernet or RS232	Ethernet or RS232	Ethernet or RS232	Ethernet or RS232	None	
Balance Connection	Ethernet, Touchscreen or RS232C	Ethernet, Touchscreen or RS232C	Ethernet, Touchscreen or RS232C	Ethernet, Touchscreen or RS232C	None	Ethernet, Touchscreen or RS232C
Network Connection	Ethernet	Ethernet	Ethernet	Ethernet	None	Ethernet
Temperature Resolution	0.0001ºC	0.0001ºC	0.0001ºC	0.0001ºC	0.002ºC	0.0001ºC
Environmental	15 - 30 °C	15 - 30 °C	15 - 30 °C	15 - 30 °C	15 - 30 °C	15 - 30 °C
Conditions	<80% humidity	<80% humidity	<80% humidity	<80% humidity		<80% humidity
Utilities						
Oxygen Purity	99.5%	99.5%	99.5%	99.5%	99.5%	99.5%
Water Purity	DI, Distilled or tap water at 85 ppm or less	DI, Distilled or tap water at 85 ppm or less	DI, Distilled or tap water at 85 ppm or less	DI, Distilled or tap water at 85 ppm or less	DI, Distilled or tap water at 85 ppm or less	DI, Distilled or tap water at 85 ppm or less

Please note that the 1109A semi micro oxygen bomb is available in the model 6725 Semimicro Oxygen Bomb Calorimeter and also in the 6269A Conversion Kit including semi-micro oxygen bomb with manual valve for the model 6200 or 6100 calorimeters.

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